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Indian Standard

GUIDE FOR MAINTENANCE AND FIELD TESTING OF ELECTRICAL RELAYS

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 7

August 1979

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Indian Standard
GUIDE FOR MAINTENANCE AND FIELD TESTING OF ELECTRICAL RELAYS

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Indian Standard
GUIDE FOR MAINTENANCE AND FIELD TESTING OF ELECTRICAL RELAYS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 16 February 1979, after the draft finalized by the Relays Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 It is essential that protective relays and their trip circuits should be periodically checked in order to ensure that they will always be ready to operate with certainty. The recommended practice is to carry out the following types of tests:

a) *Operational Test* — This is a test of simple nature to be done at frequent intervals It causes movement of the parts and checks the healthiness of the entire circuit including circuit-breaker operation; and

b) *Calibration Tests* — These are periodic tests to check the calibration and condition of the relay.

0.3 Maintenance and field testing would come under the purview of tests described in **0.2**. To enhance the use of this guide, tests on relays carried out during installation and commissioning are also included.

0.4 The figures given in this standard are typical and for guidance only.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS · 2-1960* The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This guide covers maintenance and field testing of electrical relays covered by IS . 3231-1965†. This guide is generally applicable to electromechanical relays. Static relays may need some additional requirements.

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*Rules for rounding off numerical values (*revised*).

†Specification for electrical relays for power system protection.

2. TERMINOLOGY

2.0 For the purpose of this guide, the definitions given in IS: 1885 (Part IX)-1966* and IS: 1885 (Part X)-1968† shall apply.

3. INSTALLATION AND COMMISSIONING TESTS

3.1 The aim of installation and commissioning tests is to ensure:

a) that the protective relays are in proper order subsequent to mechanical handling during transport, erection, etc;

b) that the electrical circuits associated with the relays are in healthy condition for being put into service;

c) that the result of relay action causes operation of circuit-breakers, alarms, etc; and

d) that a set of test figures for future reference is obtained, if and when necessary.

3.1.1 Some of these tests are to be repeated at periodic intervals to ensure continued healthiness of relays and circuits.

3.2 Examination and Checks

a) The relays should be examined for dents, broken glass covers, and loose parts.

b) Parts blocked for transportation should be released according to manufacturer's instructions, for example, discs of induction relays, armatures of auxiliary contactors, targets. Care should be taken so that light parts do not get bent while removing packing pieces.

c) There should be no iron-fillings in the air-gap of magnets.

d) Check that moving parts are free to move and axles have not slipped out of bearings or pivots.

e) Check that bearing housings are tight.

f) Check that air-gap clearances of disc and cup units whenever visible, are proper.

g) Check that a slight play in the axle against the bearings of induction cup or disc units is available.

h) Spring loaded bearing (usually lower one), if provided, should be checked by a gentle downwards pressure on the moving parts.

j) Handling of contact surfaces should be avoided, as contamination would impair contact making.

---

*Electrotechnical vocabulary : Part IX Electrical relays.

†Electrotechnical vocabulary : Part X Electrical power system protection.

k) Before installation, the rating, range, and auxiliary supply voltages for the relay should be checked against drawings/schedule.

m) Relays should be mounted in accordance with manufacturer's recommendations. Induction cup or disc relays should be checked for level with a spirit level after mounting.

n) Check that internal connections are tight.

p) Examine silicagel package for any change in colour.

3.3 Electrical Tests on Relays

3.3.1 Before relays are mounted and wired up, acceptance tests may be performed. The aim is to check for correctness of relay range, pick-up values, limit values of characteristics, etc, against the specifications ensuring that the relay is fit in all respects to be connected up. The test may be carried out either in a well provided laboratory or by using compact testing kits at the site itself.

3.3.2 After acceptance tests are carried out satisfactorily, a few commissioning checks are made to check healthiness of associated electrical circuits after installation.

3.3.3 Protective relays may be broadly grouped as follows:

a) *Overcurrent/Undercurrent*: Instantaneous or with time delay;
b) *Overvoltage/Undervoltage*: Instantaneous or with time delay;
c) Differential;
d) Directional;
e) Reverse power;
f) Over-frequency/Under-frequency;
g) Impedance/Mho/reactance;
h) Negative sequence;
j) Balance current;
k) DC polarized;
m) AC series;
n) Thermal; and
p) Auxiliary.

3.3.4 *List of Tests*

a) Insulation (**10.5** of IS : 3231-1965*),
b) Pick-up value (**7.1**),

---

*Specification for electrical relays for power system protection.

c) Drop-out value (**7.1**),
d) Timing (**7.2**),
e) Polarity check (**7.3**),
f) Directional unit sensitivity (**7.3**),
g) Stray torque check (**7.4**), and
h) Slope characteristic (**7.5**).

NOTE — The following tests are under consideration and their details would be added in due course

a) Characteristic,
b) Check of target indication and auxiliary contactors, and
c) Contact follow-through test.

3.3.5 *Precommissioning Tests* — The following list may be supplemented or modified in accordance with the manufacturer's instruction manuals:

Relay Type	*Tests* (*see* **3.3.4**)
Overcurrent/Undercurrent: Instantaneous Overcurrent/Undercurrent: Induction disc Overcurrent/Undercurrent: With time delay	**a, b, c, k**
Overvoltage/Undervoltage	**a, b, c, k**
Differential	**a, b, h, k**
Directional	**a, b, d, e, f, g, k, m**
Reverse power	**a, e, f, g, k, m**
Over-frequency/Under-frequency	**a, b, c, k**
Impedance/Mho/reactance	**a, b, e, j, k, m**
Negative sequence	**a, b, d, k**
Balance current	**a, b, h, k**
DC polarized	**a, b, c, k**
AC series	**a, b, c, d, k**
Thermal	**a, b, d, k**
Auxiliary	**a, b, c, k, m**

3.4 Tests on Relay Circuits — In addition to tests on individual relays, it is essential to check the complete protective circuit.

3.4.1 *Tests Before Energization* — General tests to be carried out on relay installations before energization of primary (protected) equipment are described in **3.4.1.1** and **3.4.1.2**. The aim of these tests is to check continuity of circuits, loose terminal connections, open-circuits, connection to incorrect phases, incorrect panels, incorrect circuits and continuity at all disconnecting-type links or junction boxes. After these tests are completed, no further disconnection of wiring circuits, etc, should be allowed.

3.4.1.1 *Primary injection tests* — The tests involve application of current to primary terminals of protected equipment. Current should be applied up to pick-up levels of the relays This is usually possible for current transformers. For application of voltage to voltage transformers sufficient safety precautions should be taken (*see also* **7**). Primary injection tests can also establish the polarity and ratio of current transformers.

3.4.1.2 *Secondary injection tests* — When primary injection is not practicable, secondary injection is the next best substitute. Current/voltage is applied at the secondary terminals of current transformer/voltage transformer to actuate the relays Currents to simulate fault values can be applied. In the case of voltage transformers the voltage transformer should be cordoned off and care taken to see that the voltage transformers are not overexcited from the secondary side.

For efficient working, these tests should be done with proper communication between the person near the protected equipment and the person near the relay location. One phase at a time should be checked (*see also* **7**).

3.4.2 *Tests After Energizing Primary Equipment* — Current circuits of relays, especially differential relays for generator transformer units can be checked by running the generator with low excitation and with a short-circuit placed suitably to simulate either a 'through' fault or a fault within the zone of protection. The currents through the restraining and operating coils are measured at relay terminals (*see also* **7**).

3.4.3 *Tests when Equipment is Energized and in Load Service*

3.4.3.1 Current, voltage and phase-angle measurements are made at relay terminals as a final check on correctness of all circuits.

3.4.3.2 The phase directional relay contact position should agree (contact 'made' or 'not made') with the direction of power flow in the primary circuit (provided sufficient current to actuate the relay is available).

3.4.3.3 Tests on directional ground relay (*see also* 7).

3.4.3.4 Test on differential relay to measure spill currents.

3.4.4 *Staged Fault Tests* — The protection circuits can also be tested by closing a breaker on to a fault. Appropriate oscillographic recording instruments should be provided to study the features of specific interest. However, such tests are done only when a relatively new type of protection is being tried out or when a special investigation on relay behaviour is to be carried out.

4. CALIBRATION TESTS

4.1 Purpose — A periodic check of the relay at its actual setting is needed to *ensure*:

a) healthiness of relay,
b) operation of relay targets,
c) tripping of associated circuit-breakers, and
d) operation of annunciations

4.2 Frequency of Tests — The frequency of periodic tests depends on various factors, including the following:

a) Environment, that is, temperature, humidity and pollution in the *relay-room, and whether or not the relay room is air-conditioned.*
b) Importance and size and equipment being protected.
c) Effect of maloperation of the protective circuits (whether back-up is adequate, extent of noncoordinated tripping, etc).

4.2.1 As a rough rule, when relays are operating in clean dry surroundings, a frequency of once a year is sufficient. Polluted areas may require checks twice a year, whereas back-up protection on less important circuits could be tested once in two years. The frequency may be modified in accordance with the manufacturer's advice and operating experience.

4.3 Tests

4.3.1 Secondary injection tests are made at existing set values. The tests are the same as given in **3.3.4**, except for polarity check which can be omitted, also the circle characteristic test is made at a few salient points on the characteristic.

4.3.2 When an outage of the circuit is not possible the relay characteristics can be checked by using the ' draw-out facility ', ' test-plug facility ', ' plug-in *facility* ', or by *replacing* the relay by a spare tested *unit* and testing all the relays separately, in rotation. However, since the last method does not check the control circuits connected to the relay, the full check mentioned earlier by primary/secondary injection from current transformer/voltage transformer terminals to trip the breaker, is to be preferred.

5. OPERATIONAL TESTS

5.1 Purpose — In addition to the periodic tests, it is usually advisable to make a simple ' operation ' check for testing the healthiness of dc target indications, operation of associated trip relays and breakers. Here no attempt is made to check relay characteristics.

5.1.1 These are simple checks which can be made by the operating staff of the station and do not require special instruments or specially trained staff.

5.2 Frequency of Tests — Carrying operational tests once in three months is adequate. Where the circuit concerned cannot be 'tripped' as in the case of thermal units which run for extended periods without outage, the frequency will naturally be less. However, in such cases, more thorough tests need be done when the outage is possible.

5.3 Tests

5.3.1 *Secondary Injection Test on Relays from the Panel End* — For this test a rated value of operating quantity is applied to operate the relay contacts.

5.3.1.1 Operation of relay contacts by hand is not advisable, as manual pressure may damage contact assembly and slight friction in the moving parts would remain undetected.

6. MAINTENANCE

6.0 Relays are delicate instruments and require careful handling and maintenance if the best service is to be obtained from them. Maintenance should include a general inspection of the physical condition of all parts at regular intervals. Recommended checks are given in **6.1** to **6.11**. This maintenance should be carried out every time the tests are done on the relays.

6.1 Relays are provided with dust-proof covers. Before a relay cover is removed, the relay case should be carefully dusted.

6.2 Relay interior and the magnet gaps should be free from dust, dirt and iron particles. Dust and dirt should be carefully wiped off by a soft squirrel-hair brush. The use of mechanical blower or blowing by mouth is not advised as the dust is likely to get lodged in bearings, etc, and may not be easily removable. Iron particles are removed by a feather or a stiff piece of paper.

6.3 The internal wire terminations, relay ligaments, and coil ends should be examined for sulphation or green spots caused by electrolysis. Excessive heat may result into ageing of the insulation. Green spots, sulphation marks, can be removed by wiping with trichloroethylene. The cloth used for wiping should be fluff-free.

6.4 Contact surfaces should never be handled. Polluted atmosphere usually causes black discolouration of contact surface. This does not affect contact operation. However, a special contact burnishing tool (which is a fine flexible steel strip etched on both sides with fine lines to serve as a superfine file) is used to clean the contact surfaces. Both the contacts are pressed together and the file passed in between. The file surface is then cleaned with a clean piece of paper, before using again. *Contact surfaces should be examined for accumulation of sulphides*, burrs and pitting, and corrected by using the contact burnishing tool as above. If the burrs are excessive a fine metal file can be used for dressing Abrasives should not be used as the grit may remain embedded on the contact surface.

6.5 Disc and cup unit axles should have a slight play against the bearings.

6.6 The bearings need not normally be inspected unless some defect is suspected. Bearings (guide and support) should be taken out carefully and jewel surface examined with a fine needle for cracks. For all modern relays *no lubricant is to be used for the moving parts* *The pivots and* jewels should be wiped clean with a watch repairer's cleaning stick (a soft wood stick).

6.7 Surfaces of attracted armatures and end-stops of relay moving parts should be carefully examined and wiped clean. Grime and dirt often come together to form a spot of sticky substance which can keep the moving part either in de-energized position or energized position after the relay operates.

6.8 Relay internal studs and connections should be tight.

6.9 Contact pressure, contact alignment and contact gaps should be checked against manufacturer's values

6.10 Relay targets should operate freely without friction and also reset freely.

6.11 On draw-out type relays, the finger contacts shall be carefully examined for signs of sulphation and tracking between terminals. These should be cleaned.

7. TEST PPOCEDURES

7.0 Guidelines for typical test methods are given below The test equipment required is given in Appendix A. The tests should be done at actual settings adopted at site.

7.0.1 The current source used for test of overcurrent relays should be of sinusoidal waveform. The output current waveform distortion should not exceed the following values:

Second harmonic	negligible
Third harmonic	1 percent (*Max*)
Fifth harmonic	negligible

7.1 Pick-Up Value and Drop-Out Value Tests

7.1.1 *For Instantaneous Relays* — The current/voltage should be increased gradually until the relay operates. This is pick-up value. The operating quantity should then be reduced until the relay drops off. Note the drop-off value. Voltage operated relays should be kept energized for sufficiently long time according to the manufacturer's instructions until steady-state temperature is obtained before carrying out these tests.

7.1.2 *For Induction Disc/Cup Type Relays* — The current/voltage is applied gradually and disc/cup starting and contact making values are noted. Drop-out value is also noted. The disc/cup motion should be watched; intermittent disc/cup motion may indicate some friction; or iron particles in the air gap of magnet.

7.1.3 The test values as noted in **7.1.1** or **7.1.2** should be checked against the manufacturer's values.

7.2 Timing Test — The time of operation is noted by a cycle counter or a digital timer. The timer is started at the same time as the operating quantity is applied and stopped by the relay contact operation. This is achieved by a multiple pole contactor. Contact bounce or contact chatter should be watched for and corrected. Usually the contact design and 'Wipe' would prevent contact bounce. For IDMTL relays the operating time can be checked at different values of current.

7.3 Polarity Check and Directional Unit Sensitivity — For directional relays, the correct relative polarity of current and voltage should give contact closing torque. One of the quantities should be reversed to check reversal of torque.

In-phase values of current and voltage are applied and the minimum value to close directional contact is noted.

The directional unit sensitivity is checked by the maximum torque angle test. A phase-shifter is used to determine the angle of maximum torque and the minimum value of current required to close contacts is noted. Tendency of contact to stick against the end stops should be watched. End stops should be cleaned. During this test the contact closing and contact opening zones are also noted

7.4 Stray Torque Check — Current alone is applied up to 10 to 15 times the tap value and voltage terminals are kept short-circuited. The relay should not operate Similarly, the relay should not operate when the rated voltage is applied and the current terminals are short-circuited. Manufacturer's recommendations of currrent/voltage values should be followed.

Stray contact closing torque is usually adjustable by core adjustment or by adjustment of a short-circuited turn on the core.

7.5 Slope Characteristic — Restraining current of 2 to 4 times the rated tap is applied and the operating current is applied in increasing steps till the relay operates. Both restraint and operating currents are applied suddenly. For every reading of 'slope', two readings are taken, with restraint terminals connected one way and then with restraint terminals interchanged. This is to check for any stray effects. If the restraining coils are similar the two readings of slope should be identical.

NOTE — Some types of differential relays have restraining coils having unequal burdens, and the two readings of slope would be different and should be checked against the manufacturer's curves.

7.6 Characteristic — Voltage is applied through a phase-shifter and readings of volts and amperes are taken at various phase angles, and impedance values are computed. The values are checked with the characteristic/declared by the manufacturer.

This method of test is called the static method where the parameters fed to the relay are changed gradually. However, under fault conditions there is a sudden variation of parameters applied to the relay, and the method of test which simulates these conditions is called dynamic method. The test equipment used for this method of test is briefly described in **A-2.4**.

7.7 Primary Injection Tests

7.7.1 Primary current injection tests prove that the current transformers are correctly connected to the relays (*see also* **3.4.1.1**).

7.7.2 *Precautions* — The following precautions should be taken while performing the tests:

a) A single-line diagram showing the current transformer location and the test lead connection for each test, should be made.

b) The primary equipment should be dead, that is, isolated from the high voltage system.

c) The test current may sometimes flow through current transformers other than the ones under test. Precautions are needed to prevent tripping of adjacent circuits, for example, bus differential current transformers and relays.

d) Earth fault relays, auxiliary resistors, etc, are usually of short-time ratings and suitable precautions should be taken during this test.

e) It is advisable to switch on current at a low value and to increase it slowly, in case there are any open-circuited current transformers. If the test results are different from those desired, the current should first be reduced, then switched off and the matter investigated.

f) The test connection should make good contact and connecting lead sizes should be sufficient to keep circuit impedance as low as possible. This is necessary since high currents are to be passed at low voltages.

7.7.3 *Injection of Current into a Current Transformer to Test a Relay on 'A' Phase* — Test connections should be made as given in Fig. 1A.

If sufficient primary current to operate relay is not available, the current magnitude obtained is measured by ammeter and recorded.

7.7.4 *Injection of Current into a Set of Current Transformers Forming a Circulating Current Scheme* — The test connections should be made as given in Fig. 1B.

Current is passed through 'A' phase current transformers of two feeders as shown in Fig. 1B. There should be no current in the relay.

7.7.5 *Injection of Current for Tests on Restricted Earth Fault Protection* — The test connections should be made as given in Fig. 1C.

7.7.6 *Primary Voltage Injection* — The high voltage test site should be cordoned off. The voltage transformer rating should not be exceeded. The magnitude of the high voltage applied should be available from the test set. The test connections are given in Fig. 1D.

It may not always be possible to arrange a high voltage source to test the voltage transformer at site. The ratio and phasing of the voltage transformers can then normally be checked after energization.

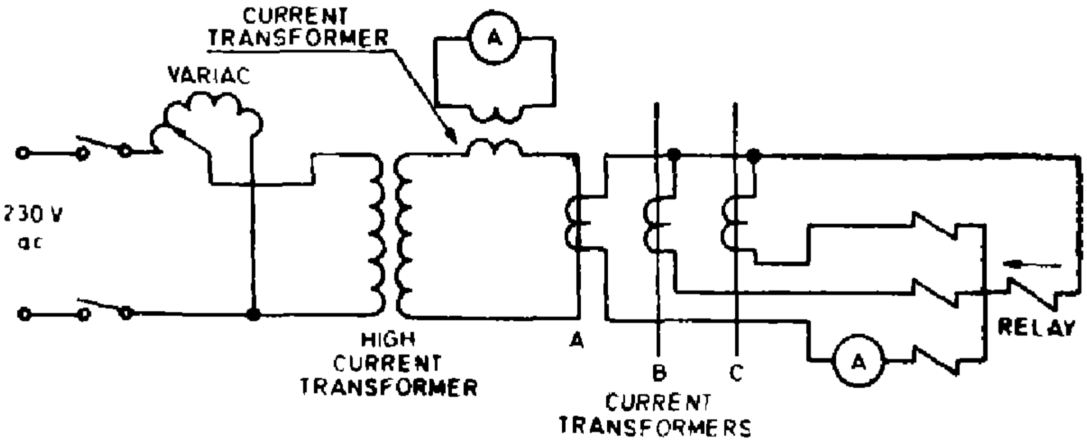
7.8 Secondary Injection Tests — The test connections should be made as shown in Fig. 2.

Test source for secondary current injection could be as indicated in **A-1**. The current magnitude is measured nearest to the relay. The current is injected at the current transformer secondary studs. Sufficient current so as to operate the relay should be passed. For full effectiveness, all auxiliary dc circuits of the relay should be in service. Target operation and circuit-breaker operation should be initiated and noted (*see also* **3.4.1.2**).

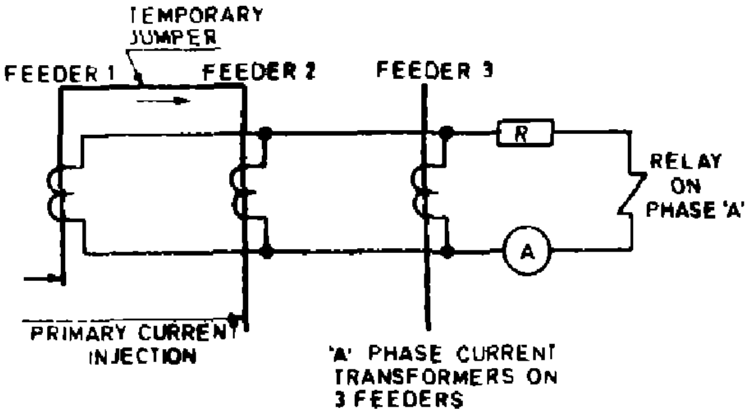
7.9 Tests After Energizing Primary Equipment — These are fundamentally primary injection tests. The generator itself is used as a test source for proving transformer and generator differential protection schemes (*see also* **3.4.2**).

7.9.1 The three phases are short-circuited, say, at location *l* as shown in Fig. 3A and generator run up, without excitation. By carefully controlling the excitation, the generator current is built up gradually. At this stage, generator differential relay currents are checked. There should be no spill currents. The generator current may be increased up to rated value of the relay. During this test the unit differential relay can also operate and therefore, it should be kept inoperative.

7.9.2 The set is shut down and the short-circuiting point is removed from location 1 and put on location 2 The test when repeated as in **7.9.1** will prove the stability of unit differential relays.

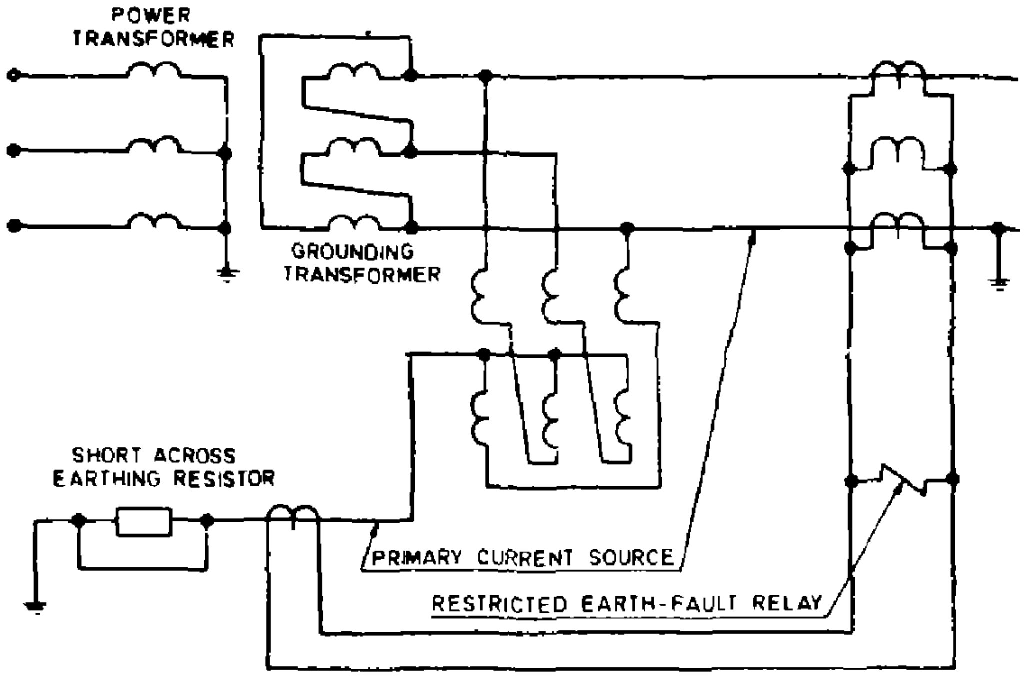


1A Injection of Current into a Current Transformer (CT) to Test a Relay on 'A' Phase

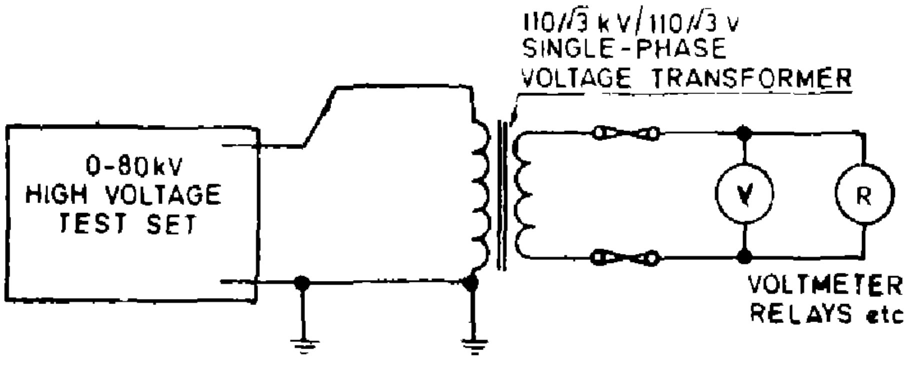

TEMPORARY JUMPER
FEEDER 1
FEEDER 2
FEEDER 3
R
RELAY ON PHASE 'A'
A
PRIMARY CURRENT INJECTION
'A' PHASE CURRENT TRANSFORMERS ON 3 FEEDERS

1B Injection of Current into a Set of Current Transformers Forming a Circulating Current Scheme

FIG. 1 PRIMARY INJECTION TEST (*Continued*)



1C Injection of Current for Tests on Restricted Earth Fault Protection


110/√3 kV/110/√3 V SINGLE-PHASE VOLTAGE TRANSFORMER
0-80kV HIGH VOLTAGE TEST SET
V
R
VOLTMETER RELAYS etc

1D Application of High Voltage

Fig. 1 Primary Injection Test

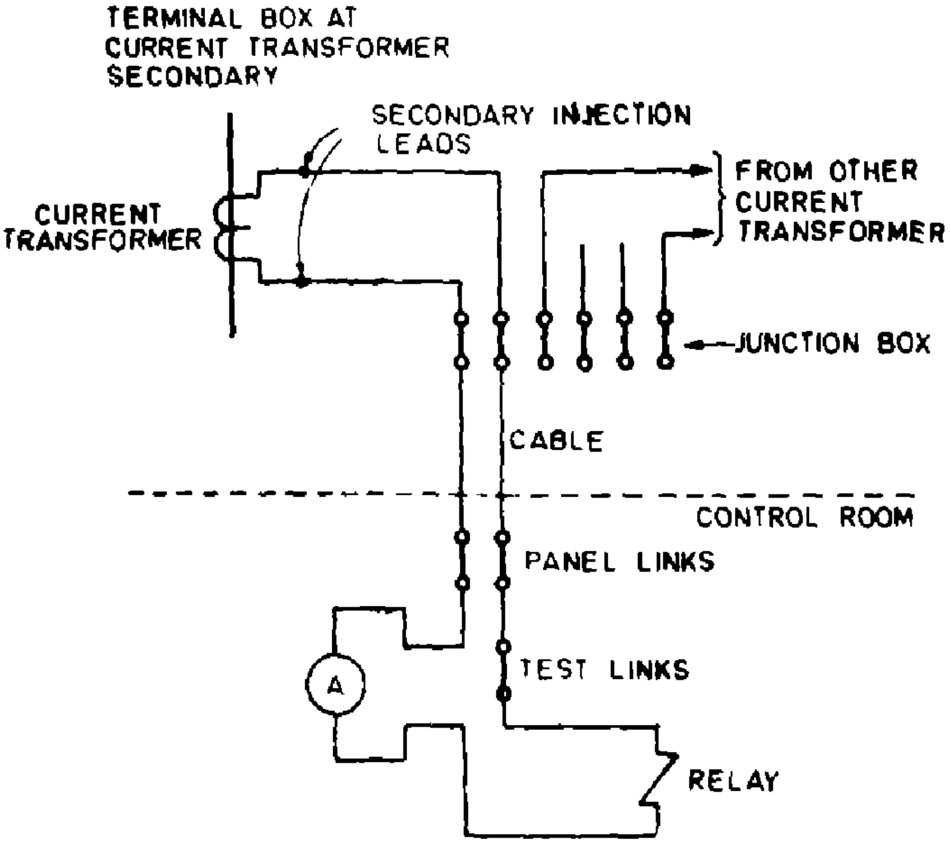

TERMINAL BOX AT CURRENT TRANSFORMER SECONDARY
SECONDARY INJECTION LEADS
CURRENT TRANSFORMER
FROM OTHER CURRENT TRANSFORMER
JUNCTION BOX
CABLE
CONTROL ROOM
PANEL LINKS
A
TEST LINKS
RELAY

FIG 2 SECONDARY INJECTION TEST

7.9.3 With only one phase connected to the ground as shown in Fig. 3B, the generator neutral ground relay may be checked.

A voltmeter is connected across relay and the generator open-circuit voltage is slowly built up to reach the pick-up value of generator ground relay. The voltage is then brought down and the set shut-down.

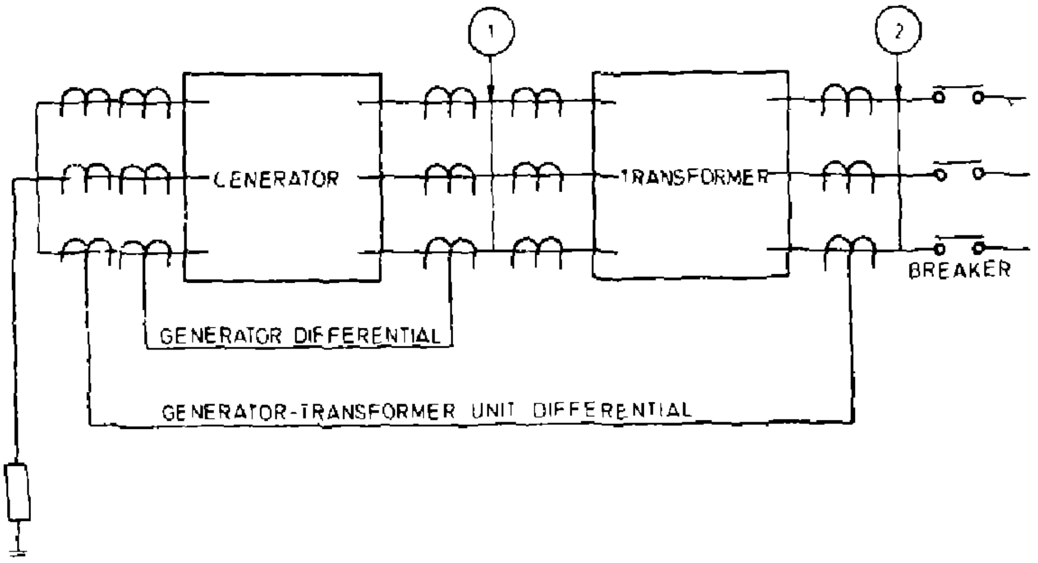
7.10 Tests When Equipment is in Load Service

7.10.1 *Phase Angle Measurement* — A phase angle meter is used to check:

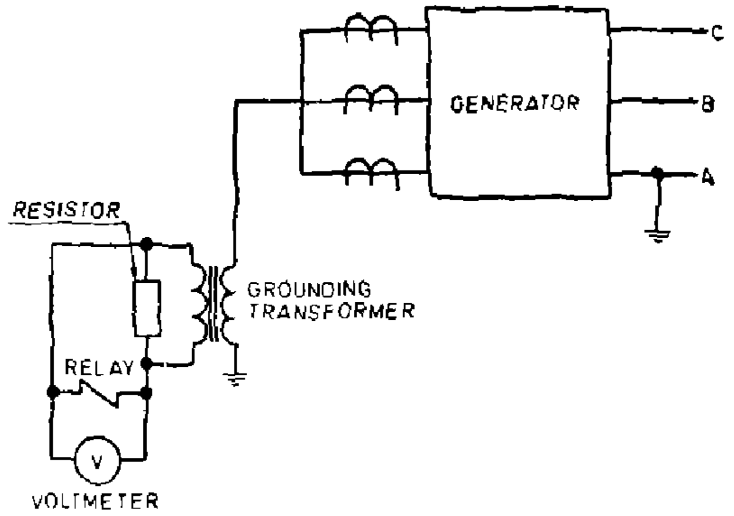
a) phase difference between relay currents and a fixed reference potential, say that of the bus voltage transformer; and

b) phase difference between currents, and potentials applied to the relay, as for directional relays

It is advisable that these checks be done on all newly commissioned relay circuits and the results recorded. At the same time the relay current is also measured by an ammeter.



3A Transformer-Generator Differential Protection Scheme



3B Test for Generator Neutral Ground Relay

FIG. 3 TESTS AFTER ENERGIZING PRIMARY EQUIPMENT

7.10.2 *Test on Directional Ground Relays* — The test connections are made as shown in Fig. 4.

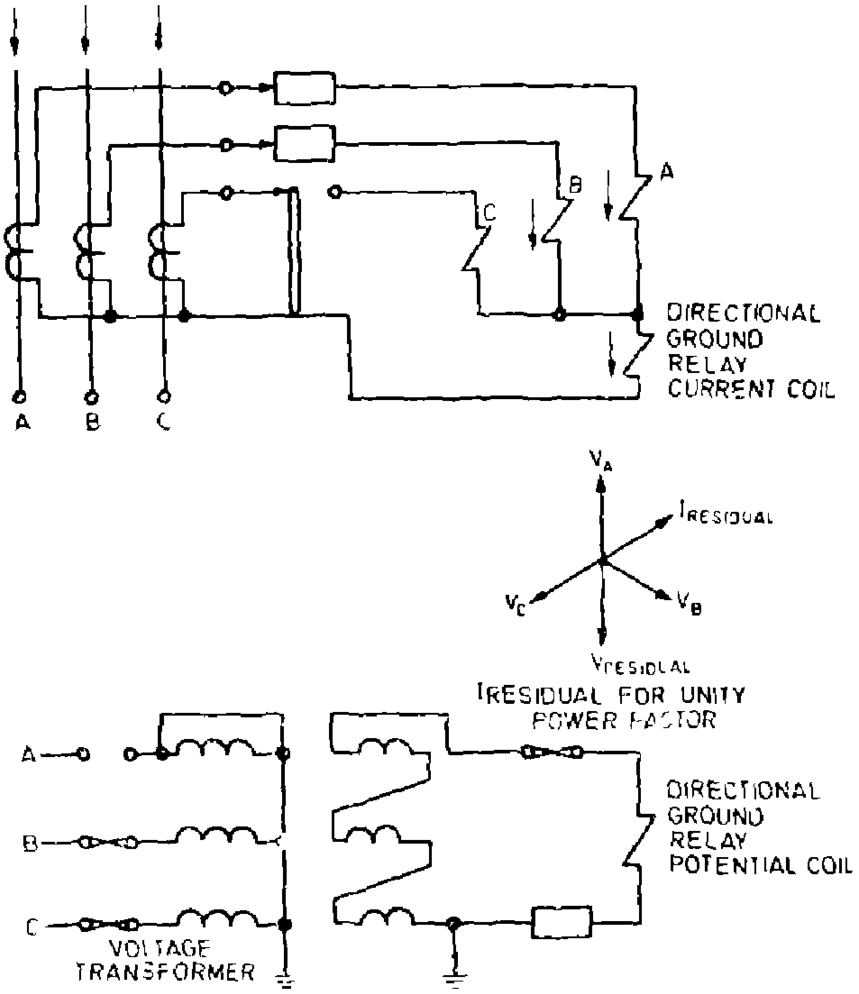

A
B
C
DIRECTIONAL GROUND RELAY CURRENT COIL
A
B
C
V_A
I RESIDUAL
V_C
V_B
V RESIDUAL
I RESIDUAL FOR UNITY POWER FACTOR
A
B
C
VOLTAGE TRANSFORMER
DIRECTIONAL GROUND RELAY POTENTIAL COIL

Fig. 4 Test on Directional Ground Relays

Phase 'A' voltage transformer fuse is removed and primary limbs short-circuited, phase 'C' current transformer is short-circuited and disconnected. When the feeder is taken in service, current passes in the relay and residual voltage also gets applied.

In most of the cases especially 110 kV and above it may not be possible to handle the primary side of the voltage transformer. In such cases the concerned secondary winding of the open delta supply may be disconnected and by-passed to get the open-delta voltage as shown in Fig. 5.

Depending upon the phase angle of the load circuit, the directional relay contact will be closed or otherwise. For this test, MW, MVAR meters or a phase angle meter is also required to get the actual vector position of load current. In this case the directional contact will close for load current phase angles between 60° lead and 90° lead, and 90° lag.

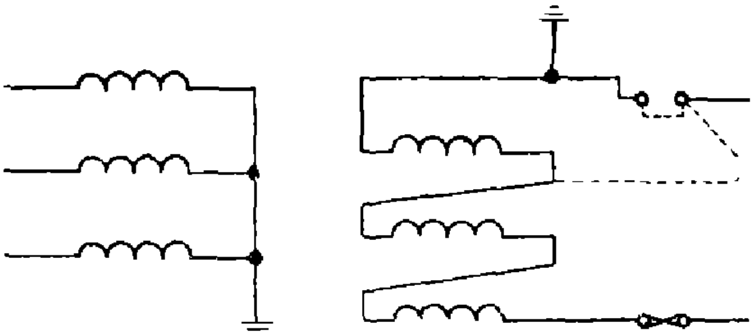


FIG. 5 MODIFICATION TO SECONDARY SIDE OF VOLTAGE TRANSFORMER FOR 110 kV AND ABOVE

8. TEST RECORDS

8.1 Actual details of test records shall be subject to agreement between the manufacturer and the purchaser. A few typical sample test record forms are shown to serve as a guide for the scope of readings involved in routine relay tests (*see* Appendices B, C and D).

APPENDIX A

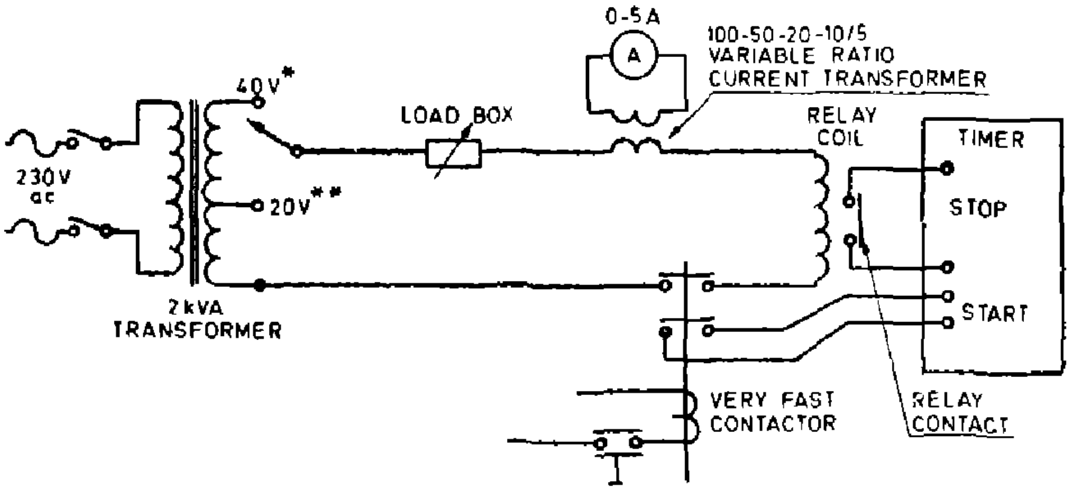
(*Clauses* 7.0, 7.6 *and* 7.8)

DETAILS OF TYPICAL TEST EQUIPMENT

A-0. Typical testing equipment needed for carrying out the tests described in this guide is given in **A-1** to **A-11**.

A-1. CURRENT SOURCE

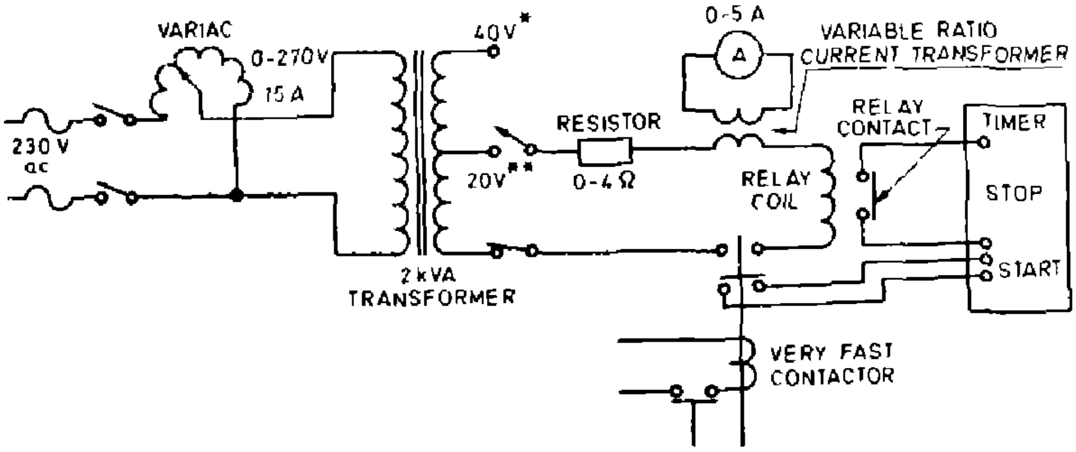
A-1.1 An adequately rated resistive load should be used for the current circuit control to keep circuit L/R as low as possible; as otherwise characteristics will be affected by high time constant of the test circuit (*see* Fig. 6A). Alternatively, if the resistive load box is unavailable, the circuit shown in Fig. 6B can be used, where a fixed value of resistance is kept in circuit The test may normally be carried out by passing two to five times the rated current.



* = Top for high value of burden

** = Top for low value of burden

6A Circuit for Current Source



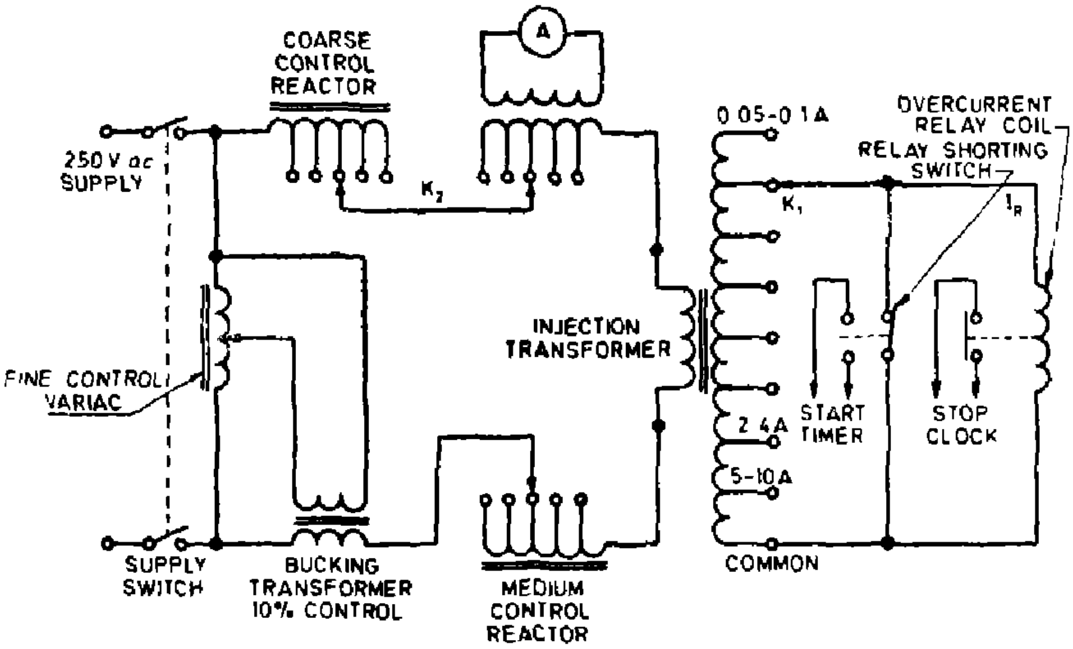
* = Top for high value of burden.

** = Top for low value of burden.

6B Alternative Circuit for Current Source

Fig. 6 Current Source

The coil impedance of many relays is non-linear which causes the test current to be distorted to a peaked waveform if the test voltage is applied directly to the relay coil or through an autotransformer. This will make test data unreliable in the case of relays whose torque is affected by the presence of harmonics. The distortion can be suppressed by connecting either a variable resistance of sufficient value or a variable non-saturating air-gap reactor in series with the relay coil. The latter method will involve less power dissipation and hence the whole equipment can be made much smaller and lighter for easy transportation. A typical connection of test equipment used is shown in Fig 7.



Relay Current I_R = Ammeter Reading (A) × $k_1 k_2$

FIG. 7 SCHEMATIC DIAGRAM OF OVERCURRENT RELAY TEST SET

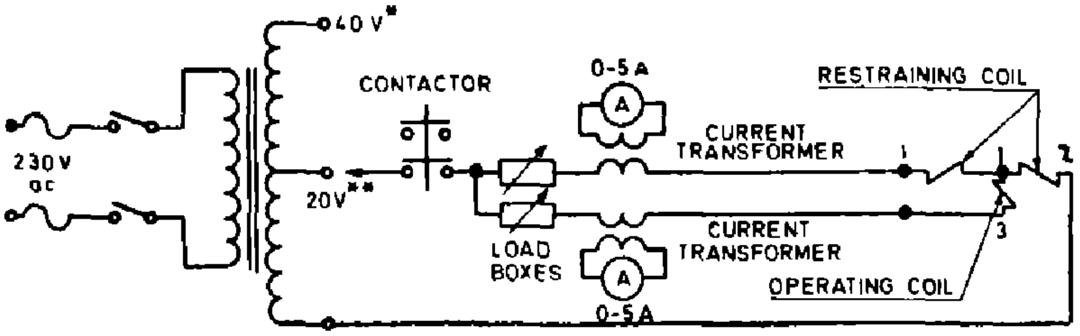
A-1.2 Current Source for Differential Relays: Balance Circuit Relays — The restraint current is first adjusted and then the operating current (*see* Fig. 8). Adjustment of one affects the current in the other to a slight extent One or two trials are usually sufficient to get the correct readings.

A-2. VOLTAGE SOURCES

A-2.1 Characteristics — Connection diagram is shown in Fig. 9A.

A-2.2 Polarity Check — Connection diagram is shown in Fig. 9B.

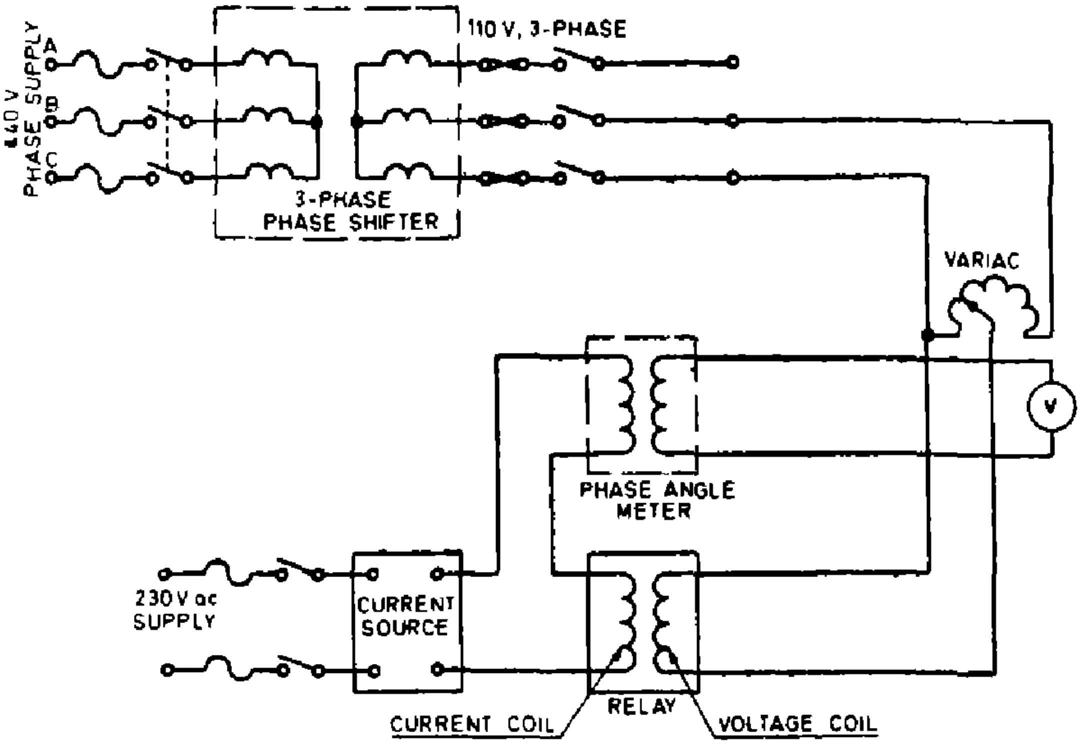
A-2.3 AC Series Relays — Connection diagram is shown in Fig. 9C.



* = Top for high value of burden.

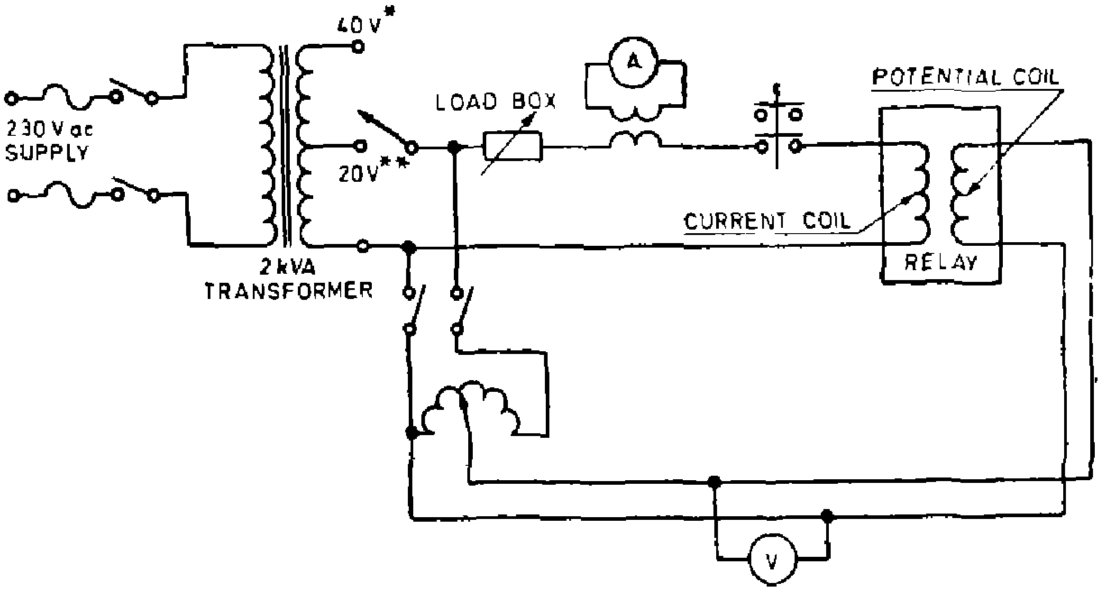
** = Top for low value of burden.

FIG. 8 CURRENT SOURCE FOR DIFFERENTIAL RELAY : BALANCE CIRCUIT RELAYS



9A Characteristics

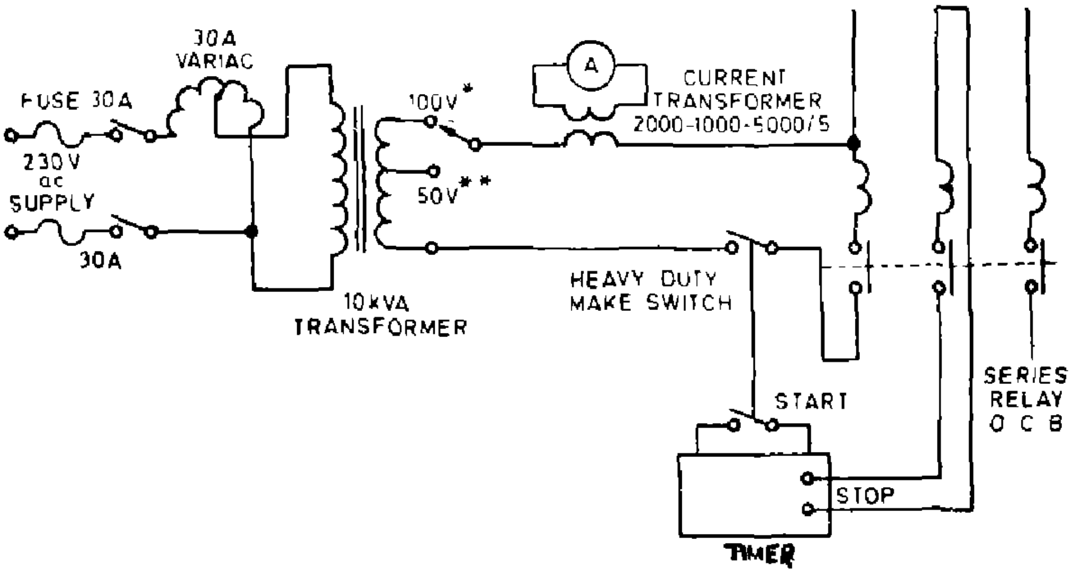
FIG. 9 VOLTAGE SOURCES (*Continued*)



* = Top for high value of burden.

** = Top for low value of burden

9B Polarity Check



* = Top for high value of burden.

** = Top for low value of burden.

9C ac Series Relays

FIG. 9 VOLTAGE SOURCES

A-2.3.1 The series relays are part of the breaker.

The breaker contacts are used to break the test current when the relay operates.

To start, the breaker is first closed and then the heavy duty make switch is used to start the relay operation and the timer; and a spare contact of the breaker is used to stop the timer.

A-2.4 A typical equipment for the dynamic testing of distance relays is shown in Fig 10. The relay is ordinarily fed with normal voltage and current. When the fault push button is pressed, the voltage applied to the relay is suddenly collapsed to that across the set fault impedance. The response of the relay to the sudden varying condition can thus be checked. By varying the values of the source impedance, the response of the relay to varying $\frac{Z_S}{Z_L}$ conditions can be simulated.

A-3. SUPPLY TRANSFORMERS

a) 1-phase, 230 V/20-40 V, 2·5 kVA (4 kVA short time)

b) 1-phase, 230 V/5-10 V, 10 kVA (20 kVA short time)

c) 3-phase, 440/110 V, delta/star, 1 kVA

A-4. PHASE SHIFTER

a) 3-phase, 440 V; or

b) 3-phase, 110 V, 1 kVA. If this rating is available, transformer mentioned in **A-3**(c) is not necessary.

A-5. CURRENT TRANSFORMER

a) Multi-ratio current transformers 100 to 20/5, 15 VA, 0·5 class — 2 numbers.

b) Multi-ratio current transformers 2 000 to 500/5, 15 VA, 0·5 class.

A-6. AUTOTRANSFORMER (VARIAC)

a) 1-phase, 0-250 V, 15 A, 2 numbers

b) 1-phase, 0-250 V, 30 A

c) 3-phase, 15 A

A-7. LOAD BOX

Suitable for 100 A short time with coarse and fine adjustments — 2 numbers.

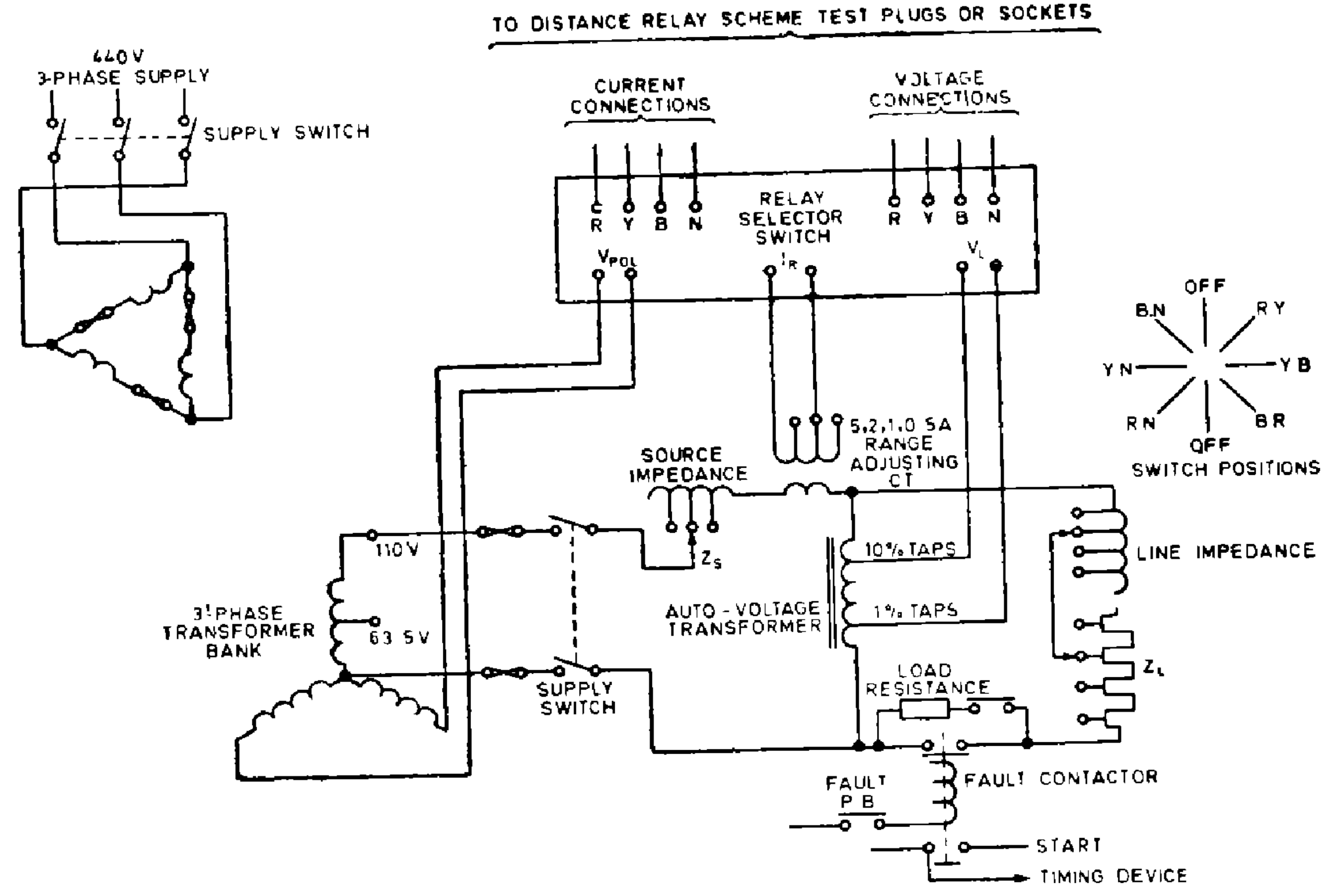


Fig. 10 Test Equipment for Distance Relays

A-8 ISOLATING SWITCHES

a) 2-pole — 2 numbers.
b) 2-pole — 2 numbers
c) 2-pole, heavy duty making switch — 1 number.

A-9. INSTRUMENTS (0·5 Class)

Description	*Numbers*
a) Clip-on ammeter, 0-5 A	1
b) Ammeter, ac, 5 A	2
c) Ammeter, dc, 1, 5, 50 A with shunts	1
d) Ammeter, ac, 100-500 mA	1
e) Ammeter, dc, 10-50-100 mA	1
f) Voltmeter, ac/dc, 5 V, 50 V, 500 V (low burden type)	1
g) Voltmeter, ac/dc, 5-50-100 mV	1
h) Phase angle meter, 0-360°, with selector for 4 quadrants	1
j) Timer, motor operated or digital type, least count 0 01 sec	1
k) 1 000 V megger for insulation test	1
m) Continuity tester	1
n) An ohmmeter to measure resistance of leads, current transformer secondary winding, stabilizing resistance, etc	1

A-10. MISCELLANEOUS

a) Contactor, 3-pole, instantaneous, 230 V, rating 100 A break.
b) Phase-sequence tester
c) Wire clips
d) Test plugs for relay testing.

A-11. TOOLS

a) Screw driver set;
b) Pliers : Nose, nipper, ordinary;
c) Set of box spanners;
d) Pincers;

e) Contact cleaners;
f) Cleaning brush;
g) Tension gauge, feelergauge, needle;
h) Inspection mirror (dented);
j) Pen torch with light bending arrangement; and
k) Spring setting tool.

APPENDIX B

(*Clause* 8.1)

TEST RECORD SHEET FOR INDUCTION OVERLOAD RELAY

Induction Overload Relay Type____ Make ____Range____
Serial No.__________Installed on __________C.T R ________

DATE OF TEST	STARTING CHARACTERISTIC			CURRENT		LEVER SETTING	OBSERVED TIME (s)	MARKED TIME (s)	SET FOR		REMARKS
	Tap	Lever	Amperes	Tap	Times Tap				Tap	Lever	

APPENDIX C

(*Clause* 8.1)

TEST RECORD SHEET FOR DIRECTIONAL RELAY

Directional Relay Type______________Make______________
Serial No ______________Installed on ______________

DATE OF TEST	POLARITY				TORQUE	TIMING AND PHASE ANGLE				REMARKS
	Current		Potential							
	Applied to Terminals	Amperes	Applied to Terminals	Volts		Current	Potential V	Current lags Voltage by angle degrees	Time (s)	

APPENDIX D

(*Clause* 8.1)

TEST RECORD SHEET FOR DIFFERENTIAL RELAY

Differential Relay____________________ Make____________________

Serial No.__________ H.T.C.T.R. __________ L.T.C T.R.__________

Range________________________ Set at________________________

Installed on____

Date of Test	Pick-up Current		Time Characteristic				Percent Slope Characteristics				Remarks
	HT	LT	Amperes			Time	Restraint Current		Opera-ting Current	% Slope	
			HT	LT	Total		HT	LT			

AMENDMENT NO. 1 APRIL 1983
TO
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Corrigenda

(*Page* 20, *Fig.* 6A *and Fig.* 6B, *matter below the circuit diagrams*) — Substitute the following for the existing matter at both the places:

* = Tap for high value of burden.
** = Tap for low value of burden.

(*Page* 22, *Fig.* 8, *matter below the circuit diagram*) — Substitute the following for the existing matter:

* = Tap for high value of burden.
** = Tap for low value of burden.

(*Page* 23, *Fig* 9B *and Fig.* 9C, *matter below the circuit diagrams*) — Substitute the following for the existing matter:

* = Tap for high value of burden.
** = Tap for low value of burden.

Alteration

[*Page* 6, *items* (a) *to* (c) *in Note under clause* 3.3.4] — Redesignate the items after (h) as:

j)
k)
m)

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